



A Hybrid Intelligent Optimization Framework for Multicropping Systems Using Genetic Algorithm, Deep Learning, and Particle Swarm Optimization

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Abstract

Multicropping optimization is a complex and multi-objective problem that involves selecting optimal crop combinations to maximize yield and profit while minimizing resource usage. This paper proposes a hybrid intelligent optimization framework integrating Genetic Algorithm (GA), Deep Learning (DL), and Particle Swarm Optimization (PSO), collectively referred to as the Neuro-Evolutionary Swarm Optimization (NESO) model. The Genetic Algorithm performs global exploration to generate diverse crop combinations, while the Deep Learning model predicts crop yield based on environmental and agricultural parameters. The Particle Swarm Optimization algorithm refines solutions by improving convergence speed and optimizing parameters. Experimental results demonstrate that the proposed hybrid model significantly outperforms individual algorithms in terms of prediction accuracy, convergence speed, and resource efficiency. The model provides an effective and scalable solution for sustainable multicropping optimization.

Keywords

Multicropping, Genetic Algorithm, Deep Learning, Particle Swarm Optimization, Hybrid Model, Precision Agriculture, Optimization

1. Introduction

Agriculture plays a critical role in ensuring food security and economic stability. With increasing population and limited natural resources, optimizing agricultural practices has become essential. Multicropping, which involves growing multiple crops simultaneously, offers significant benefits in terms of productivity and sustainability. However, selecting optimal crop combinations under varying environmental conditions is a challenging task due to its nonlinear and multi-objective nature.

Artificial intelligence techniques, particularly optimization algorithms and machine learning models, have shown promising results in addressing these challenges. Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) are widely used for optimization, while Deep Learning (DL) is effective in prediction tasks. This research proposes a hybrid framework integrating GA, DL, and PSO to improve multicropping optimization and agricultural productivity.

2. Literature Review

Previous research has explored optimization algorithms and machine learning models in



agriculture. Genetic Algorithms have been applied to crop selection and resource allocation due to their strong exploration capabilities. Particle Swarm Optimization has been used to improve convergence speed and optimize parameters in complex agricultural systems. Deep Learning models have demonstrated high accuracy in crop yield prediction by learning nonlinear relationships between environmental factors and crop performance.

However, most existing systems rely on individual algorithms or limited hybrid techniques. Comprehensive frameworks that combine prediction and optimization techniques remain limited. This study addresses this gap by proposing a hybrid GA–DL–PSO model for multicropping optimization.

3. Problem Definition

Multicropping optimization aims to identify crop combinations that maximize yield and profit while minimizing water consumption and resource usage. The problem involves multiple objectives and dynamic environmental variables such as soil conditions, seasonal variations, irrigation type, and crop characteristics.

The objective of the optimization system is to improve agricultural productivity while ensuring efficient utilization of available resources. Artificial intelligence methods are used to explore the solution space and identify the best crop combinations for specific environmental conditions.

4. Methodology

The proposed system integrates Genetic Algorithm, Deep Learning, and Particle Swarm Optimization to create a hybrid optimization framework.

The Genetic Algorithm is used to generate diverse crop combinations through evolutionary processes such as selection, crossover, and mutation. Each crop combination is evaluated using a fitness function that considers yield, profit, and water usage.

The Deep Learning model predicts crop yield using environmental and agricultural parameters. By learning complex nonlinear relationships in the data, the model provides accurate yield predictions for the crop combinations generated by GA.

Particle Swarm Optimization refines the solutions produced by GA and DL. Each particle represents a candidate solution, and its position is updated using personal best and global best values. This enables faster convergence toward optimal crop combinations.

The hybrid NESO model integrates the strengths of exploration (GA), prediction (DL), and exploitation (PSO) to achieve efficient and reliable optimization results.

5. Results and Discussion

Experimental analysis indicates that the hybrid NESO model performs better than individual algorithms. The Genetic Algorithm successfully generates diverse crop combinations but requires more iterations to reach optimal solutions. The Deep Learning model provides highly accurate crop yield predictions but lacks optimization capability. Particle Swarm Optimization converges quickly but may suffer from premature convergence.

When combined, the hybrid model balances exploration, prediction, and convergence speed. The system demonstrates improved prediction accuracy, faster convergence, and better resource optimization compared to standalone approaches. The results indicate that hybrid artificial intelligence models can significantly enhance multicropping decision-making systems.



6. Conclusion

This study proposed a hybrid intelligent optimization framework integrating Genetic Algorithm, Deep Learning, and Particle Swarm Optimization for multicropping systems. The proposed NESO model effectively improves yield prediction, convergence speed, and resource efficiency. The hybrid approach successfully overcomes the limitations of individual techniques and provides a scalable solution for sustainable agricultural optimization.

7. Future Work

Future research may incorporate climate prediction models, real-time sensor data, and reinforcement learning techniques to further improve the adaptability and performance of the system in dynamic agricultural environments.

8. References

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